

# Stabilization and Delisting of Hazardous Wastes: An Effective Approach for Reducing High Sludge Disposal Costs

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## ABSTRACT

The objective of this paper is to demonstrate that delisting (upfront or not) of hazardous waste streams (with or without stabilization or any other form of treatment) can be an effective approach for reducing high sludge disposal costs: a nonhazardous classification of the waste will reduce the disposal costs. Also, the permitting of a hazardous waste facility is extremely difficult given the strong public opposition to the siting of such facilities, while the permitting of solid waste landfills is relatively easier. Delisting a waste allows for the less rigorous disposal requirements in any solid waste landfill. Therefore, the proposed approach allows the waste to be managed in a reliable, reasonably cost-effective and environmentally prudent manner.

A facility may petition the U.S. EPA to remove its waste from hazardous waste control by excluding them from the lists of hazardous wastes contained in 40 CFR § 261.31 and § 261.32. In addition, residues from the treatment, storage or disposal of listed hazardous wastes and mixtures containing hazardous wastes are considered hazardous wastes. Such wastes are also eligible for exclusion. Petitioners must provide sufficient information to the U.S. EPA to allow the Agency to determine: (1) that the waste to be delisted is not hazardous based upon the criteria for which it was listed, (2) that no other hazardous constituents are present in the waste at levels of regulatory concern and (3) that the waste does not exhibit any hazardous waste characteristics.

The U.S. EPA encourages the use of upfront delisting petitions because they have the advantage of allowing the applicant to know what treatment levels for constituents should be sufficient to render specific wastes nonhazardous before investing in new or modified waste treatment systems. Therefore, upfront delisting allows new facilities to receive exclusions prior to generating wastes which, without upfront exclusions, would unnecessarily be considered hazardous.

On July 18, 1991, the U.S. EPA proposed the use of the U.S. EPA's Composite Model for Landfills (the U.S. EPACML) to evaluate a delisting petition and to evaluate the impact of the petitioned waste on human health and the environment. The use of the U.S. EPACML by the delisting program provides consistency between the characteristics and delisting programs. The new model allows a two to three times higher dilution than the previously used Vertical and Horizontal Spread (VHS) model.

This paper presents case studies from several industry sectors where the above methodology has greatly benefitted the manufacturer.

## INTRODUCTION

The hazardous waste list from nonspecific and specific sources is published in 40 CFR §261.31 and §261.32. These wastes are listed as hazardous because they typically and frequently exhibit one or more of the characteristics of hazardous wastes identified in Subpart C of

Part 261 (i.e., ignitability, corrosivity, reactivity and toxicity characteristic [TC] toxicity) or meet the criteria for listing contained in 40 CFR §261.11(a)(2) or (a)(3).

Individual waste streams may vary, however, depending on raw materials, industrial processes and other factors. Thus, a specific waste from an individual facility meeting the listing description may not be hazardous. Under 40 CFR §260.20 and §260.22, facilities may petition the U.S. EPA to remove their wastes from hazardous waste control by excluding them from the lists of hazardous wastes contained in 40 CFR §261.31 and §261.32. In addition, residues from the treatment, storage or disposal of listed hazardous wastes and mixtures containing hazardous wastes are also considered hazardous wastes. Such wastes are also eligible for exclusion. Petitioners must provide sufficient information to the U.S. EPA to allow the Agency to determine: (1) that the waste to be delisted is not hazardous based upon the criteria for which it was listed, (2) that no other hazardous constituents are present in the waste at levels of regulatory concern and (3) that the waste does not exhibit any hazardous waste characteristics.<sup>1,2</sup>

## U.S. EPA's Approach Used to Evaluate Delisting Petitions

The U.S. EPA will first evaluate the petition to determine whether the waste is hazardous based on the factors for which it was originally listed. The Agency will then evaluate the waste with respect to other factors, including constituents other than those for which the waste was listed. The petitioner can choose to submit a raw materials list and process descriptions or to test the waste for waste constituents likely to be present. The U.S. EPA will evaluate this information to determine whether any hazardous constituents are used or formed in the manufacturing and treatment process and are likely to be present in the waste at environmentally significant levels.<sup>3</sup>

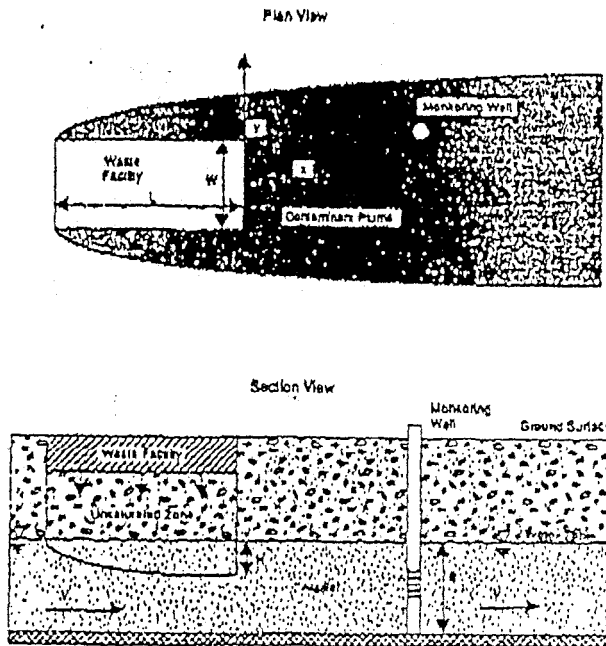
A petitioner may also request an upfront delisting, i.e., for waste that has not yet been generated or that will be subject to further treatment. An upfront delisting (when treatment is planned) allows an exclusion to be granted based on untreated waste characteristics, bench-scale or pilot-scale treatment data, process descriptions and batch testing requirements to show that, once on-line, a treatment system can meet the U.S. EPA's verification testing limitations.<sup>4</sup>

The U.S. EPA encourages the use of upfront delisting petitions because they have the advantage of allowing the applicant to know what treatment levels for constituents should be sufficient to render specific wastes nonhazardous before investing in new or modified waste treatment systems. Therefore, upfront delisting allows new facilities to receive exclusions prior to generating wastes which, without upfront exclusions, would unnecessarily be considered hazardous. Upfront delistings for existing facilities can be processed concurrently during construction or permitting activities. Therefore, new or modified treat-

ment systems should be able to produce wastes that are considered nonhazardous sooner than otherwise would be possible. At the same time, conditional batch testing requirements to submit data verifying that the delisting levels are achieved by the fully operational manufacturing/treatment systems will guarantee the integrity of the delisting program and will ensure that only nonhazardous wastes are removed from Subtitle C control.<sup>1</sup>

#### PROPOSED USE OF the U.S. EPACML FOR DELISTING EVALUATIONS

During a delisting determination, the U.S. EPA uses fate and transport models to predict the concentration of waste constituents that may be released from petitioned wastes after disposal to determine the potential impact on human health and the environment. The main component of the U.S. EPA's modeling effort is the estimation of the potential impact of the leachable waste constituents on an underlying aquifer. The modeling exercise involves the use of leachate concentrations as inputs to the model to predict constituent concentrations in the groundwater at a hypothetical drinking water well located downgradient from the disposal site. These compliance-point concentrations are then compared to the health-based levels (HBLs) for the waste constituents of concern. Figure 1 shows the plan view and the cross-sectional view of the waste facility and leachate migration through the unsaturated and saturated zones.<sup>2</sup>



Source: USEPA, Office of Solid Waste, 1990

Figure 1  
A Schematic of the Waste Facility and Leachate Migration  
Through the Unsaturated and Saturated Zones

Under a landfill or surface impoundment disposal scenario, the exposure route of most concern to the agency is ingestion of contaminated groundwater. The U.S. EPA has been using the Vertical and Horizontal Spread (VHS) model to approximate the transport of constituents in an aquifer below the waste disposal site.<sup>3</sup> The VHS model predicts the dilution of the waste constituents in a drinking water aquifer as a result of dispersion in the vertical and horizontal directions.

On July 18, 1991, the U.S. EPA proposed the use of their Composite Model for Landfills (the U.S. EPACML) to evaluate a delisting

petition and to evaluate the impact of the petitioned waste on human health and the environment. The use of the U.S. EPACML by the delisting program provides consistency between the characteristic and delisting programs. The new model allows a two to three times higher dilution than the previously used VHS model.<sup>4,5</sup>

#### Description of the U.S. EPACML

The EPACML model simulates the fate and transport of constituents released from a waste disposal facility into the underlying aquifer and the migration to a hypothetical drinking water well. Under the delisting program, it is assumed that the waste would be disposed in a subtitle D (i.e., a municipal solid waste landfill) landfill. The U.S. EPACML accounts for one-dimensional steady and uniform advective flow; contaminant dispersion in the longitudinal, lateral and vertical directions; sorption onto aquifer material; and chemical degradation from hydrolysis.<sup>3,4</sup> No volatilization or biodegradation of chemicals is assumed. The model estimates a Dilution/Attenuation Factor (DAF) for chemicals which basically represents the estimated reduction in concentration that would occur during transport through soil and groundwater from the leachate release point (bottom of the landfill or surface impoundment) to an exposure point.<sup>4</sup> A range of DAFs is normally obtained due to the various types of aquifers, soils and waste constituents that are simulated. The U.S. EPACML uses a Monte Carlo simulation technique to account for the wide range of hydrogeologic settings found at municipal waste landfills and to account for the uncertainty in the input data.<sup>3,4</sup>

#### Dilution/Attenuation Factors (DAFs)

The U.S. EPACML Monte Carlo simulation yields a probability distribution of DAFs, and thus a DAF percentile needs to be selected. The characteristic program used the 85th DAF to set regulatory levels. The delisting program is proposing to use the 95th percentile DAFs which the U.S. EPA believes to be a conservative and reasonable worst-case disposal scenario for delisted wastes. Figure 2 shows the DAF curve for both landfills and surface impoundments. Table 1 lists representative DAF values for selected waste volumes.

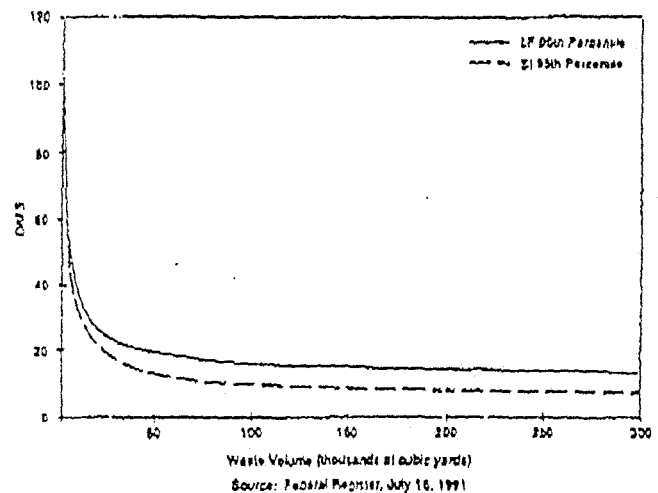


Figure 2  
Dilution/Attenuation Factors for Delisting  
EPACML-Landfill and Surface Impoundment

#### ERM's RECOMMENDED APPROACH TO STABILIZATION AND DELISTING

Environmental Resources Management, Inc. (ERM) recommends the use of a phased approach to handle the complex issues associated with treating and disposing of a waste. The first step of that approach is the waste characterization, where representative samples of the waste

are taken and analyzed for total and leachable concentrations of the constituents that could potentially be present in the waste. The second step is the comparison of the leachate concentrations with the delisting levels. This step determines whether or not the waste could be excluded from Subtitle C regulations. If the leachable constituent levels are greater than the delisting levels, the manufacturer has the option to consider further treatment, waste segregation, etc., so that the delisting levels are met. If the decision for further waste treatment is made (such as stabilization), ERM performs a technology screening that identifies technologies capable of achieving the delisting levels. The next step in the process is the performance of bench-scale combustion testing (if applicable), bench-scale stabilization testing, etc. If the treatability results are encouraging, this step is followed by the preparation of the delisting petition and submission of the petition to the U.S. EPA. If the petition is granted, a full-scale treatment facility (if applicable) is designed and permitted.

This paper presents case studies from several sectors of industry where the above methodology has proven of great benefit to the waste producer.

Table 1  
Dilution/Attenuation Factors for Landfills  
and Surface Impoundments

Waste Volume (Cubic Yards per Year)	95th Percentile	
	Landfills	Surface Impoundments
1,000	100*	100*
1,250	96	100*
1,500	90	95
1,750	84	90
2,000	79	84
2,500	74	78
3,000	69	72
4,000	63	65
5,000	57	59
6,000	54	54
8,000	48	48
10,000	43	43
12,500	40	40
15,000	36	36
20,000	32	32
25,000	29	29
30,000	27	27
40,000	24	24
50,000	22	22
60,000	20	20
80,000	18	18
100,000	16	16
150,000	14	14
200,000	13	13
250,000	12	12
300,000	12	12

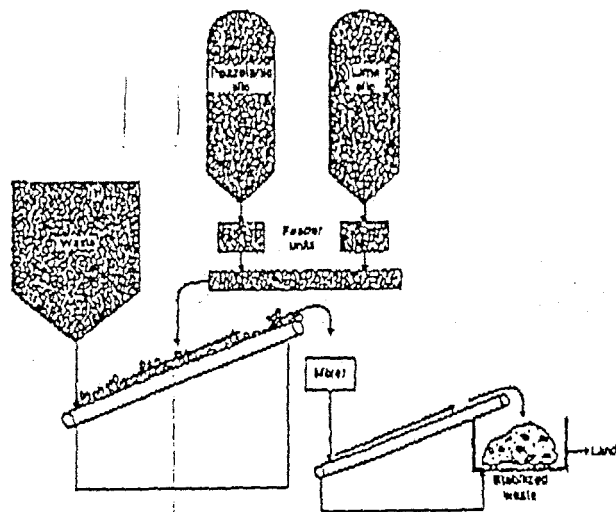
\* DAF Outfall is 100 corresponding to the Toxicity Characteristic Rule (Fed. Reg., Thursday, March 29, 1990).

Source: Fed. Reg., Vol. 56, No. 135, pg. 32,000, Thursday, July 13, 1991.

#### Case Study 1--Upfront Stabilization and Delisting of a Chromium Filter Cake

A steel manufacturer's chromium wastewater treatment plant currently generates approximately 240 wet tons/yr of filter cake from its wastewater treatment operations. This filter cake is currently classified as a U.S. EPA Hazardous Waste Code F006, Wastewater Treatment Sludges from Electroplating Operations and, accordingly, must be managed as a hazardous waste. The listed constituents of concern for U.S. EPA Hazardous Waste No. F006 are cadmium, hexavalent chromium, nickel and cyanide (complexed). The generated waste contains chromium(III) produced from the reduction of spent chromium passivation and plating solutions.

The steel manufacturer has developed a chemical stabilization process for the filter cake whereby the hazardous constituents in the filter cake are rendered virtually immobile. This process is based on the pozzolanic reaction of lime and fly ash that adsorbs and/or encapsulates the heavy metals present in the chromium filter cake into a calcium-alumino-silicate matrix, thereby rendering them essentially immobile. The product of this reaction is identified as Chemically Stabilized Filter Cake (CSFC). Figure 3 shows a schematic diagram of a typical lime-based (pozzolanic) stabilization process that could be used for this project.<sup>3</sup> ERM prepared a delisting petition on behalf of the manufacturer for excluding the CSFC from the list of hazardous wastes. ERM believes this material to be nonhazardous, as substantiated by the detailed data and information contained in the delisting petition file.



Source: USEPA, 1989

Figure 3  
Lime-Based (Pozzolanic) Stabilization Process

The steel manufacturer has completed an investigatory program to produce and test a statistically significant number of representative demonstration samples of the subject CSFC. Laboratory tests were conducted on four representative samples of chromium filter cake. Each sample (1,000 g) was mixed with controlled amounts of fly ash (400 g), lime kiln dust (600 g) and water in a predetermined series of steps. The resulting mixtures were immediately subjected to EP Toxicity and TCLP testing according to the methods in 40 CFR Part 261.24 and 55 Federal Register, 11798-11877, March 29, 1990, respectively. Also, the stabilized cake was allowed to cure for 15 days and then subjected to further EP Toxicity and TCLP testing. In addition, the manufacturer performed EPTox extractions on the four cured, stabilized materials after pulverizing them to pass a 100-mesh sieve.

Results of the EP Toxicity tests for arsenic, cadmium, chromium, lead, mercury, nickel and silver are shown in Table 2. EP Toxicity and TCLP testing were not completed for barium and selenium due to the sufficiently low total constituent concentrations (i.e., assuming the 20:1 liquid-to-solid ratio of the EP Toxicity and TCLP tests and the assumption of 100% leaching, the absolute worst-case extract concentrations would be below the respective levels of regulatory concern). As can be seen from Table 2, the extract concentrations from both tests are well below 100 times the applicable Health Based Level (HBL) (the HBLs are multiplied by a dilution/attenuation factor equal to 100 that was based on a maximum annual volume of 800 yd<sup>3</sup> of stabilized chromium filter cake). The modeled compliance point concentrations that were obtained by using the maximum EPTox or TCLP leachate concentrations from the stabilized materials are well below the corresponding levels of regulatory concern.

Table 2  
Comparison Between Health-Based Levels  
and Extracted (EP) Concentrations\*

Compound:	Silver	Arsenic	Cadmium	Chromium	Mercury	Nickel	Lead
HBL	0.05 mg/L	0.05	0.005	0.1	0.002	0.1	0.05
HBLx100**	5	5	0.5	10	0.2	10	5
Raw Chromium Filter Cakes							
EP TOX Test ---							
I.D.	1200	<0.05	<0.02	<0.02	12.7	<0.002	0.30
	2200	<0.05	<0.02	<0.02	6.8	<0.002	0.14
	3200	<0.05	<0.02	<0.02	12.2	<0.002	0.16
	4200	<0.05	<0.02	<0.02	5.4	<0.002	0.16
Stabilized Material - Uncured							
EP TOX Test ---							
I.D.	1420	<0.05	0.02	<0.02	<0.05	<0.002	0.14
	2420	<0.05	0.03	<0.02	<0.05	0.002	0.14
	3420	<0.05	0.02	<0.02	<0.05	0.004	<0.10
	4420	<0.05	<0.02	<0.02	<0.05	0.003	0.10
Stabilized Material - 15 Day Cure							
EP TOX Test ---							
I.D.	1440	<0.05	<0.02	<0.02	<0.05	<0.002	0.10
	2440	<0.05	<0.02	<0.02	<0.05	<0.002	<0.10
	3440	<0.05	<0.02	<0.02	<0.05	<0.002	0.10
	4440	<0.05	<0.02	<0.02	<0.05	<0.002	0.10
Stabilized Material - 15 Day Cure - <100 mesh							
EP TOX Test ---							
I.D.	1470	<0.05	<0.02	<0.02	<0.05	<0.002	<0.10
	2470	<0.05	<0.02	<0.02	<0.05	<0.002	<0.10
	3470	<0.05	<0.02	<0.02	<0.05	<0.002	<0.10
	4470	<0.05	0.02	<0.02	<0.05	<0.002	<0.10

\* All constituent concentrations are expressed in ppm.

\*\* The factor of 100 represents a dilution/attenuation factor (DAF) obtained by use of the EPACML model.  
HBL = Health Based Level (USEPA, 1990).

Nine-day Multiple Extraction tests (MEP) were performed on the four samples to simulate the hypothetical long-term effects of leaching by acid rain or other acidic media. The results show that the metals in the leachate from the CSFC remain well below 20 times the HBL after nine successive extractions. A 24-hr distilled water extraction test for total cyanide content was also performed on the four stabilized samples. No cyanide was detected (the detection limit was 0.02 mg/L).

The maximum total cyanide concentration in the stabilized materials was 52 ppm which is below the U.S. EPA's interim standard for reactive cyanide of 250 ppm. Also, the maximum total sulfide concentration in the stabilized materials was 160 ppm for reactive sulfide.

It should be further emphasized that the chromium reduction system, which is a necessary part of the process at the chromium treatment plant, is established to effectively reduce hexavalent chromium. The chromium in the raw chromium filter cake is at least 99.96% trivalent chromium. Trivalent chromium, which is a natural constituent in the earth's crust and is an essential human nutrient, is considered to be much less toxic than hexavalent chromium (see *Federal Register* 53, p. 10,206, March 29, 1988). ERM, therefore, does not believe that levels of total chromium in the petitioned CSFC present a hazard to either human health or the environment.

Since organics are not used in the plating lines and at the chromium wastewater treatment plant, no Appendix VIII Organics are expected to be present in the stabilized filter cake (CSFC) in environmentally significant quantities. The Material Safety Data Sheets (MSDSs) for the lubricants used at the plating lines were thoroughly examined by ERM. The MSDSs indicate that no toxic chemical is present in the lubricating oils in concentrations >0.1%. These facts, in combination with the maximum levels of total oil and grease that were found in the stabilized filter cake (i.e., 990 ppm), indicated that no volatile organics or semivolatiles are expected to be present in the stabilized filter cake in environmentally significant levels.

Based upon the data and information presented in the petition, ERM concluded that the chromium CSFC does not meet the criteria for which the U.S. EPA Hazardous Waste Code F006 was listed in 40 CFR Part 261.32, nor does it meet any other hazardous criteria/characteristics (e.g., with respect to all other TC metals, ignitability, reactivity, corrosivity, nickel, cyanide or organics) which might cause the waste to be hazardous. In addition, the materials and substances used in the manufacturing and treatment processes are not expected to introduce any additional constituents (e.g., organics) that would be of concern. The subject stabilized waste "is not capable of posing a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed." ERM, therefore, believes that this material should not be classified as a hazardous waste. The delisting petition was submitted in order to support this conclusion and form the basis for a finding by the U.S. EPA that the chromium treatment plant filter cake treated by the stabilization process merits delisting.

#### Case Study 2—Ash Stabilization and Delisting

This case study focuses on the potential applicability of delisting of ash (either bottom ash, fly ash or a mixture of both fly ash and bottom ash) that is generated by combusting a variety of wastes such as municipal solid waste, pharmaceutical industry waste, etc. The goal in these situations is to apply solidification and/or stabilization techniques to reduce leaching of constituents (primarily metals) from the ash. The wastes that could be incinerated can be either listed wastes (such as F-listed wastes) or nonlisted solid wastes. Many times even though a nonlisted waste is being incinerated, the ash fails the EPTox or TCLP testing and is, therefore, declared hazardous. This consequences for the ultimate disposal of the ash. As emphasized in the introduction to this paper, stabilization of a hazardous ash can be an effective approach to reducing high sludge disposal costs and allows

for the less rigorous disposal of the ash in any solid waste landfill.

Table 3 shows bench-scale leaching results on stabilized incinerator fly ash.<sup>a</sup> The fly ash is created from the burning of up to 2000 tons/day of municipal solid waste at a waste-to-energy facility in Massachusetts. As is shown in that table, the fly ash falls the delisting levels for cadmium, chromium and lead. Therefore, this ash should be handled as a hazardous waste or be subjected to further treatment

Table 3  
Comparison Between Health-Based Levels  
and Extracted (TCLP) Concentrations<sup>a</sup>

Compound:	Cadmium	Chromium	Lead
MCL:	0.005	0.1	0.05
MCLx100.0 <sup>b</sup>	0.5	10	5
TCLP Test: Untreated Incinerator Fly Ash			
1A	0.49	<0.01	0.87
1B	3.3	<0.01	4.4
1C	44.9	13	697
1D	7.02	29	3305
TCLP Test: Stabilized Fly Ash - Uncured			
1A	0.05	<0.01	0.30
1B	0.05	<0.01	0.30
1C	0.11	<0.01	0.45
1D	0.28	<0.01	0.75
TCLP Test: Stabilized Fly Ash - 17 Day Cure			
1A	<0.05	<0.05	<0.10
1B	<0.05	<0.05	<0.10
1C	<0.05	<0.05	<0.10
1D	<0.05	<0.05	<0.10

<sup>a</sup> All constituent concentrations are expressed in ppm.

<sup>b</sup> The factor of 100.0 represents a dilution/attenuation factor (DAF) obtained by use of the EPACHL model.

MCL = Health Based Level (USEPA, 1990).

to remove the hazardous properties. The owners of the plant have patented a stabilization technology that involves mixing the fly ash (or combinations of fly ash and bottom ash) with quality controlled waste pozzolans and landfill leachate (or water) to produce a waste that passes stabilized ash. It can be seen that the uncured and 17-day cured fly ash produces leachate concentrations for the three metals that are below the respective delisting levels. Therefore, the stabilized ash can be handled as a nonhazardous waste and be disposed of in any hazardous waste landfill at a savings of at least \$100/ton of fly ash.

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